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ABSTRACT

This study was undertaken to better understand what happens when teachers implement a reform curriculum designed specifically to communicate mathematics content and pedagogy to teachers. More specifically, the study focuses on what aspects of the curriculum materials teachers consider as they decide what they will enact in the classroom. Information was gathered to determine the extent to which teachers were understanding the main mathematical content of their first unit on number, the kinds of thinking that students were intended to develop, and how useful the supporting materials embedded in the curriculum were in helping them enact the curriculum. The findings in this study about what teachers learn from this supporting information should be of interest to researchers, curriculum developers, and professional development providers as they consider ways to support teachers' implementation of reform curricula. (Author)

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WHAT DO ELEMENTARY TEACHERS LEARN FROM REFORM MATHEMATICS TEXTBOOKS?

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This study was undertaken to better understand what happens when teachers implement a reform curriculum designed specifically to communicate mathematics content and pedagogy to teachers. More specifically, the study focuses on what aspects of the curriculum materials teachers consider as they decide what they will enact in the classroom. Information was gathered to determine the extent to which teachers were understanding the main mathematical content of their first unit on number, the kinds of thinking that students were intended to develop, and how useful the supporting materials embedded in the curriculum were in helping them enact the curriculum. The findings in this study about what teachers learn from this supporting information should be of interest to researchers, curriculum developers, and professional development providers as they consider ways to support teachers' implementation of reform curricula.

Research in the last two decades on teachers' use of mathematics textbooks necessarily utilized traditional textbooks as the teachers' main resource. Findings from these studies indicate that teachers often make major alterations to the textbook lessons resulting in an "enacted" curriculum that looks very different from the intended curriculum (Ball, 1988; Grant & Kline, 2002; Remillard, 2000). In addition, the teachers struggled to create a coherent and effective "enacted" curriculum. Therefore, suggestions were made to include in current reform textbooks more information to help teachers learn and to support their creation of an "enacted" curriculum.

In considering what types of information might be useful to teachers, Davenport and Sassi (1995) made available a collection of approximately 600 resources (articles, videotapes, curriculum materials, etc.) to a group of elementary teachers as they worked to think differently about mathematics teaching and learning. The teachers were allowed to choose which resources they wanted to explore and submit reflective writings on the usefulness of these resources. The majority of teachers chose resources that used a narrative structure to provide concrete images of classroom discussions, student thinking, and common misconceptions. Clearly narratives, as an external resource, had a powerful impact on teacher learning. However, it remains to be seen what impact this type of information could have on teacher learning if imbedded within curriculum materials and how this type of information might effect the enacted curriculum teachers create. This study investigates this issue by considering the following question: what about reform curriculum materials do teachers consider and how does this material impact their thinking?

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Methodology

Context

This study takes place in the context of a three year funded project designed to support more than 325 teachers and administrators in six local school districts (urban, suburban, rural, public, and private) as they work to improve mathematics teaching and learning. These districts all adopted one of the National Science Foundation-funded reform curricula, *Investigations in Number, Data and Space* (henceforth called *Investigations*), which focuses on reasoning and problem solving where students are encouraged to make sense of the mathematics they are learning and to use procedures that they understand, rather than those they may have memorized but may not fully understand. One of the goals of this curriculum is to communicate mathematics content and pedagogy to teachers by including information, often in narrative form, describing the importance of particular content, describing various strategies students may use and why they work, discussing connections among topics, and providing sample conversations a teacher may have with a student or group of students on a particular mathematical idea. The curriculum is structured into separate modules focusing on particular mathematical topics. There are 6 - 11 modules at each grade level with at least two at the lower elementary level and at least three modules at the upper elementary level focusing on number.

Data

All 329 K-5 teachers in the 6 districts in the project were sent a survey asking them to analyze one module at their grade level. One hundred and twenty-three teachers completed and returned the surveys, representing 5 of the 6 districts in the project in grades K, 1, 3 and 5, and all 6 districts in grades 2 & 4. These teachers represented a range of years teaching in general as well as teaching *Investigations*, although the majority of teachers were less experienced with the curriculum. Sixty-one percent of the teachers who returned surveys had only 1-2 years experience using *Investigations*, while the others had 3 or more years experience, and often more than 5. The first module on number at each grade level was chosen for the analysis, because they involved a topic every teacher would certainly deem important and there was a guarantee that every teacher would actually teach the modules since they appeared in the beginning of the school year.

The intent of the survey was to gather information on what the teachers were considering in each particular module. One section of the survey focused on what teachers thought of the information provided to them in the curriculum materials, referred to as Teacher Notes (TNs) and Dialogue Boxes (DBs). The TNs provide information typically on the mathematics content and on the ways in which children think about the content. The DBs provide examples of classroom discussions around the content. Each survey included a list of all the TNs and DBs in the unit, the number of which

ranged from 13 in grade 3 to 30 in grade 1, and asked that teachers rate each item as to its usefulness, on a scale of 1 to 4 if they had read the item; otherwise, they were to indicate that the item was "never read." The teachers were then asked to choose, and provide a rationale for their choice, the TN/DB that they found most helpful and the one they found least helpful. A second section of the survey asked the teachers to reflect on the unit as a whole and describe the mathematics content the students learn, the specific strategies or ways of thinking about number that were developed in the unit, and their overall impressions of the unit.

Approximately a year later, a short follow-up survey was administered asking teachers to assess the helpfulness of a variety of different factors in their efforts to implement the *Investigations* curriculum. They had to rank, from 1 to 4, the helpfulness of: reading the information provided in the curriculum materials; attending various forms of professional development; observing their students during implementation; and talking with other teachers.

Analysis

TNs and DBs

The teachers' ranks for TNs and DBs from 1 to 4 were segregated into ranks of 1 and 2 (generally not useful) and ranks of 3 and 4 (generally useful). The averages for teachers overall as well as the averages by grade level were analyzed for any patterns that would indicate the types of TNs or DBs teachers were choosing as useful or not. Explanations for the teachers' choices of most or least helpful TN or DB were coded into 6 general categories—mathematical content understanding, pedagogical understanding, understanding student thinking, management, time, and general comments. Mathematical content understanding referred to explanations that expressed an enhanced understanding of the teacher's own mathematics. Pedagogical understanding referred to explanations that expressed a better grasp of how to teach the material at hand. Understanding student thinking was used when teachers explained that the TN or DB helped them interpret different types of student responses and what those indicate about the students' understanding. Management and time were used when teachers explained that a TN or DB helped them with management, such as organizing materials, assigning partners, etc., or when they helped them structure the time spent on any given activity in the lesson. Finally, explanations were coded as general when they were not specific to a particular TN or DB. For example, some teachers simply stated that they use all of the TNs and DBs or that they liked this feature in the curriculum in general.

Within these categories, responses were also coded as to whether the teachers had a more critical or negative impression of the TNs or DBs or whether they simply disagreed with the information given in them. For example, a response that was coded as negative for pedagogical understanding was "This shows students thinking aloud, but

it doesn't give any help for students who are stuck." Another example of a response that was coded as negative was "I was still confused about what I was supposed to get the students to understand." Finally, these explanations were analyzed by looking for trends among the teachers overall as well as by looking for trends among less experienced teachers (1-2 years experience with *Investigations*) and more experienced teachers (3 or more years experience).

Description of Mathematical Emphasis of Unit and Student Strategies

The teachers' descriptions of the mathematical intent of the unit and the strategies students learned after completing the unit were also coded. The teachers' descriptions of the mathematics were coded to represent the extent to which they captured the mathematical emphasis of the unit. A 4 represented a detailed description of content or a well-developed characterization of big ideas; a 3 represented a description of some big ideas but may have other less developed descriptions included, or a good list; a 2 represented lists with little description, often including less important ideas; a 1 represented no identification or description of big ideas; and a 0 was used for no answer or negative comments.

These descriptions were also analyzed by looking for trends among the teachers overall as well as by looking for trends among less experienced teachers (1-2 years experience with *Investigations*) and more experienced teachers (3 or more years experience).

The descriptions of student strategies were coded for their level of persuasiveness. A response was coded as "persuasive" if it contained a detailed description of the idea or used names of strategies that were well understood and "not persuasive" if it seemed to focus narrowly on more insignificant mathematical ideas or strategies or missed important ideas. Some examples of descriptions that were "not persuasive" were "It utilizes children's many ways of looking at the world and making sense of it" and "I think the emphasis on the idea of more than one way to solve/record results from activities an important concept for children to know." The first example does not describe a strategy per se and the second example speaks about the teacher's objectives rather than strategies.

Results and Discussion

What Materials Were Considered?

In general, the teachers read the majority of TNs and DBs in their unit and rated them as being useful in implementing *Investigations*. See Table 1. The largest proportion of unread TNs and DBs occurred in kindergarten. This may be due to the fact that these units were published last so that many of the teachers had not been able to read all of the support materials in that particular unit. The teachers were also very willing to rate some TNs and DBs as not useful (those rated 1 & 2). There was no pattern in

the ratings they made, except that many rated TNs dealing with management issues, such as storing manipulatives, etc., as not useful (or perhaps not necessary).

This overall impression of the TNs and DBs being useful is further supported by the teachers' reasons for their choice of most helpful TN or DB. As Table 2 illustrates, the majority of teachers' reasons dealt mainly with the substantive issues of understanding how children think and orchestrating classroom discourse. In particular, the teachers appreciated seeing sample student work and commented on the usefulness of

Table 1. Usefulness of TNs and DBs

Teacher Notes (TNs)						
	K	**First**	**Second**	**Third**	**Fourth**	**Fifth**
Total # of TNs	12	21	11	7	10	13
TNs rated 3 & 4	77%	71%	72%	67%	69%	68%
TNs rated 1 & 2	23%	29%	28%	33%	31%	32%
Unread of TNs	24%	6%	10%	1%	3%	6%
Dialogue Boxes (DBs)						
Total # of DBs	7	9	5	6	4	6
DBs rated 3 & 4	69%	80%	70%	61%	69%	67%
DBs rated 1 & 2	31%	20%	30%	39%	31%	33%

Table 2. Reasons for Choosing TN/DB as "Most Helpful"

	K	**1**	**2**	**3**	**4**	**5**
helped understand the mathematics content better	14%	6%	13%	16%	42%	30%
helped understand how children think or what they might do	43%	25%	58%	42%	19%	20%
helped make pedagogical decisions related to classroom discourse	36%	56%	23%	37%	31%	40%
helped with general management	7%	14%	6%	5%	8%	10%

having examples of how to handle incorrect answers. Although many teachers felt that the supporting materials also helped them understand mathematics content better, this was more pronounced in the upper grades.

Finally, there did not seem to be any preference for TNs versus DBs. Overall, TNs were chosen as most or least helpful about 70% of the time. This is in keeping with the general proportion of TNs to DBs in each of the units in that typically 67% of the supporting materials in each unit are TNs. This was the case at all grade levels for most helpful, and all but one grade level for least helpful. Grade 3 teachers chose DBs as being least helpful at a higher rate than TNs. In this case the results are understandable as one DB was from an excursion lesson (which is skipped by most teachers) and the other was the first DB in the unit, which is purposefully simplistic.

These results were also analyzed according to years of experience with the curriculum. One might assume that more experienced teachers would make different choices than less experienced teachers in identifying supporting materials that were most helpful or least helpful. For example, more experienced teachers who have had more time to understand the content and student thinking might rely more on the DBs to help them facilitate richer discussions. However, there was no difference in the choices made by less experienced versus more experienced teachers. It could be the case that the more experienced teachers identified what had impacted them the most in all their years of teaching rather than what impacted them in their most recent year of teaching. This would basically remove the effect that experience might have on the teachers' choices.

How Did the Materials Impact the Teachers?

Describing Mathematical Emphases of the Units

In general, the majority of teachers (69%) were able to identify and describe the important mathematical emphases of the units at their grade level. Their descriptions referred to such topics as recognizing and using landmark numbers to navigate the number system, developing number sense, and understanding the meaning of the operations. Some teachers, particularly at the primary level, had difficulty distinguishing between actual content goals versus such process goals as problem solving, communicating, and representing. Although they were asked to describe the mathematics content they thought students would learn, close to 28% of the K-2 teachers' responses dealt with process goals. Grade two teachers spoke more about processes than any other grade. In addition, kindergarten teachers often discussed the notion of "representing quantities with pictures, numerals or words." While this is an important process goal in the curriculum, it can be problematic if teachers are focusing on this without thinking about the mathematics content children are using and exploring by doing the representations. This may suggest that it is necessary to make a stronger distinction between content and process goals in curriculum materials.

The results of analyzing teachers' descriptions of the mathematical intent of the units according to their levels of experience with the curriculum are shown in Table 3. Overall the more experienced teachers were better able to describe the mathematical emphases of their units. This suggests that there is an effect of experience on understanding of content, or at least the ability to describe that content well. As Table 3 shows, this result holds true for all grade levels except kindergarten. In light of the fact that there is only one kindergarten teacher with 3 or more years experience, this exception is not significant. Any additional analysis of grade level variations, like the fact that more experienced second and fifth grade teachers seemed to show particular strength in describing the mathematical emphases in their units, does not seem reasonable given the relatively small numbers of teachers at any particular grade level.

Finally, there were four teachers (two more experienced, two less experienced) who commented negatively about the mathematics content in some of the units. Their comments focused on two issues: some believed that the content of the first number module was mainly review; others felt that there was not enough practice with memorizing basic facts. Both issues speak to a major philosophical difference between reform-based curricula and traditional curricula – the reform-based curricula are purposefully designed to provide students with more time developing both conceptual and procedural ideas before encouraging students to work towards fluency.

Table 3. Quality of Description of Mathematical Emphases of Units

Teachers with 1-2 Years Experience with Investigations							
	K	1st	2nd	3rd	4th	5th	K-5
Ranked 3 or 4	77%	50%	64%	53%	77%	50%	64%
Ranked 1 or 2	11%	50%	28%	47%	23%	25%	33%
Negative	0%	0%	7%	0%	0%	25%	3%
Total # of Teachers	8	12	14	15	13	4	66
Teachers with 3 or More Years Experience with Investigations							
Ranked 3 or 4	0%	60%	92%	67%	77%	100%	78%
Ranked 1 or 2	100%	40%	8%	33%	0%	0%	17%

So, for example, in *Investigations* students are expected to develop fluency in single digit addition by the end of second grade only after spending two years working on addition. They memorize some facts and developing efficient retrieval strategies for those facts they do not have memorized throughout this time. This is contrasted with the practice of drilling addition facts in first and second grade before students have had time to develop their own strategies. These concerns are fairly typical for teachers first encountering a reform-based curriculum. The fact that there were not more negative comments by the less experienced teachers is most likely due to two factors: teachers with these negative opinions about the units may have been less likely to fill out the survey, and all teachers sent this survey were part of a long-term professional development project which addressed these concerns.

Description of Student Strategies

When asked to describe specific strategies or ways of thinking about number that their students developed during their unit, the teachers were generally able to identify important strategies. Overall, 82% of the teachers who responded to the question were able to provide persuasive descriptions of these strategies. For example, a persuasive response related to using relationships among problems was "using landmark factor pairs, like 2 x 25 and 2 x 50, and building on those to pairs like 40 x 25, 40 x 250, 20 x 50 and 20 x 500." Those responses that were not persuasive often focused on content issues rather than student strategies.

Other Factors Impacting Teachers Learning

One may argue that it is difficult to tease out which factors are really impacting teachers' learning as they implement a new curriculum and specify the impact of the curriculum materials themselves. For example, there is no question that teachers also learn from the professional development in which they participate as well as from working with their students as they experience the activities in the curriculum. In a follow-up survey on which teachers were asked to rank (on a scale of 1-4) the impact of some of these factors on their implementation efforts, reading the curriculum materials (average rank 3.3) was second only to talking to other teachers (average rank 3.5). This suggests the teachers certainly value the supporting curriculum materials and find them to be a critical component in their efforts to implement the curriculum. Having said this, it is important to point out that the professional development experienced by these teachers did make deliberate use of these supporting materials on occasion, and thus may have influenced the value teachers placed on them.

Conclusion

The supporting materials in the *Investigations* curriculum clearly had a significant impact on the teachers, demonstrating that it is possible to produce curriculum materials that help teachers learn at the same time as supporting them in teaching. The

teachers' choices of most helpful TNs and DBs, and their rationales for those choices, focused on the issues the curriculum developers intended – the mathematics content, ways of thinking students might display, or pedagogical support – rather than less substantive issues of general management and time. In addition, the fact that more experienced teachers were better able to describe the mathematics content focus of their units suggests that teachers continue to learn and deepen their understanding the more they use the curriculum materials. However, many teachers' propensity to blend content and process goals suggests that more discussion is required in the curriculum materials themselves to help teachers distinguish among these ideas. Finally, it would be useful to conduct a similar study with teachers who were not part of a long-term professional development project to better assess the impact of professional development on their interpretation of the curriculum in general, and the supporting materials in particular.

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